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UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

WINET LABS LLC,

Plaintiff,

v.

APPLE INC.,

Defendant.

Case No. 5:19-CV-02248-EJD

SECOND AMENDED COMPLAINT FOR PATENT INFRINGMENT

Parties

1. Plaintiff WiNet Labs LLC ("WiNet Labs"), is a Wyoming company with its principal place of business in Newtown, Pennsylvania.

2. Apple Inc. is a California corporation with its principal place of business in Cupertino, California.

Jurisdiction and Venue

3. This action arises under the patent laws of the United States, 35 U.S.C. §§ 101 *et seq*.

4. This Court has subject matter jurisdiction over this action under 28 U.S.C. §§ 1331 and 1338(a).

5. This Court may exercise personal jurisdiction over Apple, which conducts continuous and systematic business and has headquarters located in California and this District. These patent infringement claims arise directly from Apple's continuous and systematic activity in this District. In short, this Court's exercise of jurisdiction over Apple would be consistent with the California long-arm statute and traditional notions of fair play and substantial justice.

6. Venue is proper in this District pursuant to 28 U.S.C. § 1400(b).

Claim of Patent Infringement

7. WiNet Labs is the exclusive owner of United States Patent No. 7,593,374 (the "'374 patent"), which is attached hereto as "Exhibit A."

8. The '374 patent is valid and enforceable.

9. Apple has and is directly infringing claims of the '374 patent. Apple practices the methods embodied in the claims of the '374 patent. Without limiting the claims that may be asserted or the services that may be accused of infringement in this action, Apple is infringing Claim 1 of the '374 patent when Apple makes, uses, and sells its "Personal Hotspot" service.

Apple delivers the accused "Personal Hotspot" service through software within the possession, custody, and control of Apple. To deliver the "Personal Hotspot" service, Apple does *not* rely on hardware, software, or firmware within the possession, custody, or control of Apple product users. As demonstrated below, the "Personal Hotspot" software practices each step of the method of Claim 1 of the '374 patent. According to the Licensed Application End User License Agreement, Apple owns and controls the "Personal Hotspot" service and associated software, granting a license to the software to the Apple device user.

10. As outlined below, the "Personal Hotspot" service—which consists of hardware, software, and firmware owned and controlled by Apple—automatically practices each step of Claim 1 of the '374 patent. In the following example, a telephone made, used, and sold by Apple (an iPhone) contains the "Personal Hotspot" service running on the device. The "Personal Hotspot" service running on the iPhone automatically performs the steps of the Claim 1 method if the iPhone is turned on and the "Personal Hotspot" service is enabled.

a. Claim 1 is, "A method for forming an ad-hoc network with a plurality of nodes, the method comprising . . . ." (Ex. A, col. 8:50-51.) The "Personal Hotspot" service practices Claim 1's method of forming an ad-hoc network with a plurality of nodes. For example, the "Personal Hotspot" service on an iPhone forms an ad-hoc network among the iPhone and an iPad and a MacBook Air. The "Personal Hotspot" service on the iPhone is comprised of software, and this service performs each step of the Claim 1 method.

b. Claim 1 includes "electing a coordinating node from the plurality of nodes . . . ." (Ex. A, col. 8:52.) The iPhone, the iPad, and the MacBook Air include "nodes," which allow these devices to send and receive data among other devices. "A node **100** enables the electronic device to send data to, and

receive data from, other electronic devices that are equipped with nodes **100**." (*Id.*, col. 2:35-37.) Based on the "Personal Hotspot" software on the iPhone initiating the shared connection with the iPad and the MacBook Air, as well as the iPhone's serial number, the "Personal Hotspot" software elects the iPhone as the coordinating node. This "electing" step is performed automatically by the "Personal Hotspot" service running on the iPhone. For example, when a user named John carries the iPhone into the same room as the iPad and the MacBook Air, each of the iPad and the MacBook Air will automatically display an icon entitled "John's iPhone," which is the name of an ad-hoc network address over which John's iPhone has automatically been elected the coordinating node. No user action was required for the iPhone to be elected the coordinating node.

c. In Claim 1, "the electing step comprises . . . emitting pings from each of the nodes to locate nodes within a radio range . . . ." (Ex. A, 8:61-62.) The iPhone, the iPad, and the MacBook Air each have an antenna and a transceiver. A "ping" is a computer network administration software utility that is used to test the reachability of a host on an Internet Protocol (IP) network. The "Personal Hotspot" service running on the iPhone emits pings to locate other devices within the iPhone's radio range. The "Personal Hotspot" service running on the iPhone in fact located the iPad and the MacBook Air as being within radio range, as evidenced by a display on the iPhone that the iPad and the MacBook Air were within radio range. The iPad and the MacBook Air came into radio range when John carried his iPhone into the room in which the iPad and MacBook Air were

located. The "Personal Hotspot" service running on the iPhone emits the pings automatically, without any user action.

d. In Claim 1, "the electing step comprises . . . broadcasting a tag from each of the located nodes to identify each of the located nodes . . . ." (Ex. A, 8:62-63.) Apple's "Personal Hotspot" service broadcasts serial numbers from each of the iPhone, the iPad, and the MacBook Air. These serial numbers—tags—are a means by which the accused software on the iPhone identifies the iPhone to the iPad and MacBook Air. These serial numbers—tags—are a means by which the accused software on the iPad identifies the iPad to the iPhone and MacBook Air. These serial numbers—tags—are a means by which the accused software on the MacBook Air identifies the MacBook Air to the iPhone and the iPad.

e. In Claim 1, "the electing step comprises . . . sending out an election-ballot packet by each of the identified nodes to each of the other identified nodes. . . ." (Ex. A, 8:64-65.) Along with the broadcasted tags, the accused software on the iPhone, the iPad, and the MacBook Air sends an election-ballot packet to one another. The packet is a data structure that includes the rule that the accused software will use to elect the iPhone, the iPad, or the MacBook Air as the coordinating node.

f. Claim 1 continues, "wherein the electing step further comprises electing the coordinating node based on information in the tags, wherein each of the tags includes a serial number, the election step further comprises electing the coordinating node based on its serial number." (Ex. A, col. 8:66-9:3.) The accused software running on the iPhone initiated the "Personal

Hotspot," and the tag associated with the iPhone includes the iPhone's serial number. The accused software on the iPhone elects the iPhone the coordinating node based on the iPhone's serial number.

g. Claim 1 continues, "the coordinating node then: assigning an ad-hoc network address to each of the other nodes with the ad-hoc address recognizing participation of a respective node in the network . . . ." (Ex. A, col 8:52-56.) The "Personal Hotspot" service assigns a name—e.g., "John's iPhone"—to the iPad and MacBook Air as an ad-hoc network address.

h. Claim 1 includes "assigning a local address to each of the other nodes with the local address setting a position of a respective node in the network . . . ." (Ex. A, col. 8:57-59.) The "Personal Hotspot" service assigns the IP address of 172.20.10.1 to the iPhone. The "Personal Hotspot" service also assigns the iPad the IP address of 172.20.10.2, and the MacBook Air the IP address of 172.20.10.4.

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Prayer for Relief

WHEREFORE, WiNet Labs prays for the following relief against Apple:

(a) Judgment that Apple has directly infringed the '374 patent;

(b) For a fair and reasonable royalty;

(c) For pre-judgment interest and post-judgment interest at the maximum rate allowed by law;

(d) For such other and further relief as the Court may deem just and proper.

/ / / /

Demand for Jury Trial

WiNet Labs demands a trial by jury on all matters and issues triable by jury.

Date: February 26, 2020

/s/ Todd C. Atkins

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EXHIBIT A

US007593374B2

(12) **United States Patent**
Zhang et al.

(10) **Patent No.: US 7,593,374 B2**
(45) **Date of Patent: Sep. 22, 2009**

(54) **MULTI-TO-MULTI POINT AD-HOC WIRELESS DATA TRANSFER PROTOCOL**

(75) Inventors: **Lin Zhang**, Beijing (CN); **Bob S. G. Chou**, Newtown, PA (US); **Haoxiang Zhang**, Beijing (CN); **Zhe Yu**, Beijing (CN); **Lei Yang**, Beijing (CN)

(73) Assignee: **WiNet Labs Ltd.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 412 days.

(21) Appl. No.: **11/121,837**

(22) Filed: **May 2, 2005**

(65) **Prior Publication Data**

US 2005/0254471 A1 Nov. 17, 2005

Related U.S. Application Data

(60) Provisional application No. 60/566,897, filed on Apr. 30, 2004.

(51) **Int. Cl.**
H04Q 7/24 (2006.01)
H04J 1/16 (2006.01)
H04Q 7/00 (2006.01)

(52) **U.S. Cl.** **370/338**; 370/255; 370/331; 370/252

(58) **Field of Classification Search** 455/550.1, 455/520, 445, 41; 370/338, 254, 344, 230, 370/401, 225, 395.4, 331, 458, 389; 709/222, 709/204

See application file for complete search history.

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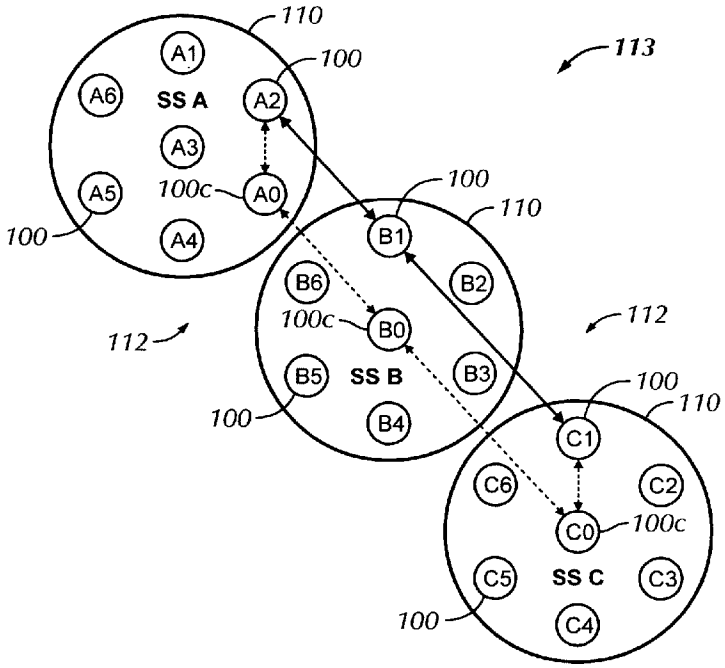
Primary Examiner—Charles N Appiah
Assistant Examiner—Kiet Doan

(57) **ABSTRACT**

A wireless communication system utilizes a protocol for creating a multi-to-multi point, extendable, ad-hoc wireless network. A hardware platform enables an electronic device to connect in an ad-hoc network. Accordingly, each electronic device with such a hardware platform of a plurality of such electronic devices functions as node in a network. The nodes function according to the protocol for form ad-hoc networks and to communicate data therebetween.

20 Claims, 8 Drawing Sheets



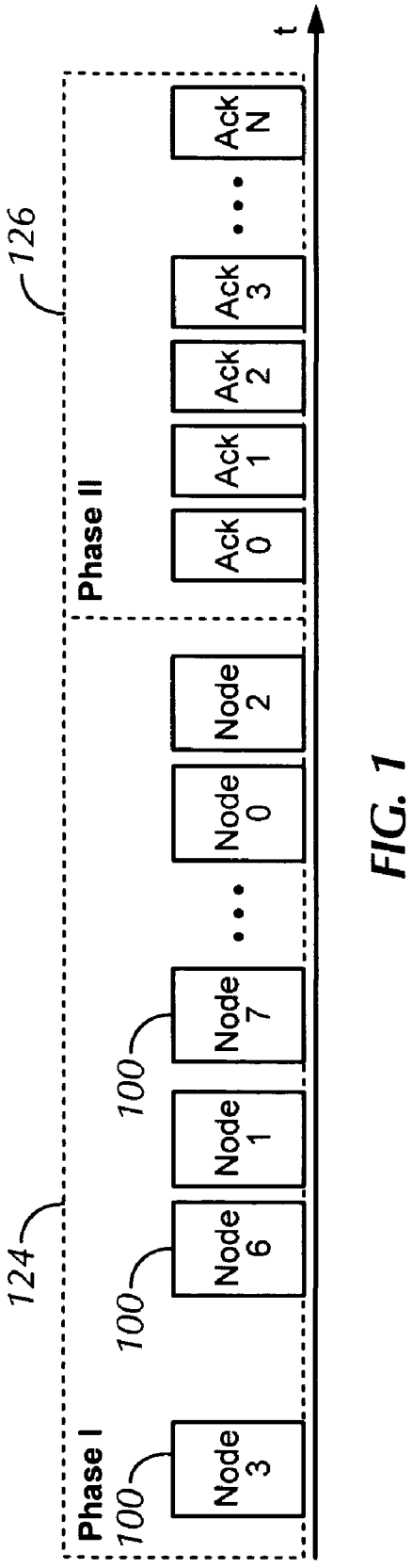

t
126
Phase II
Ack N
Ack 3
Ack 2
Ack 1
Ack 0
Node 2
Node 0
Node 7
Node 1
Node 6
Node 3
Phase I
100
100
100
124

FIG. 1

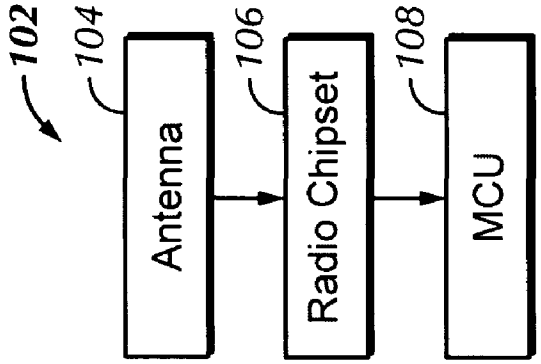

102
104
Antenna
106
Radio Chipset
108
MCU

FIG. 2

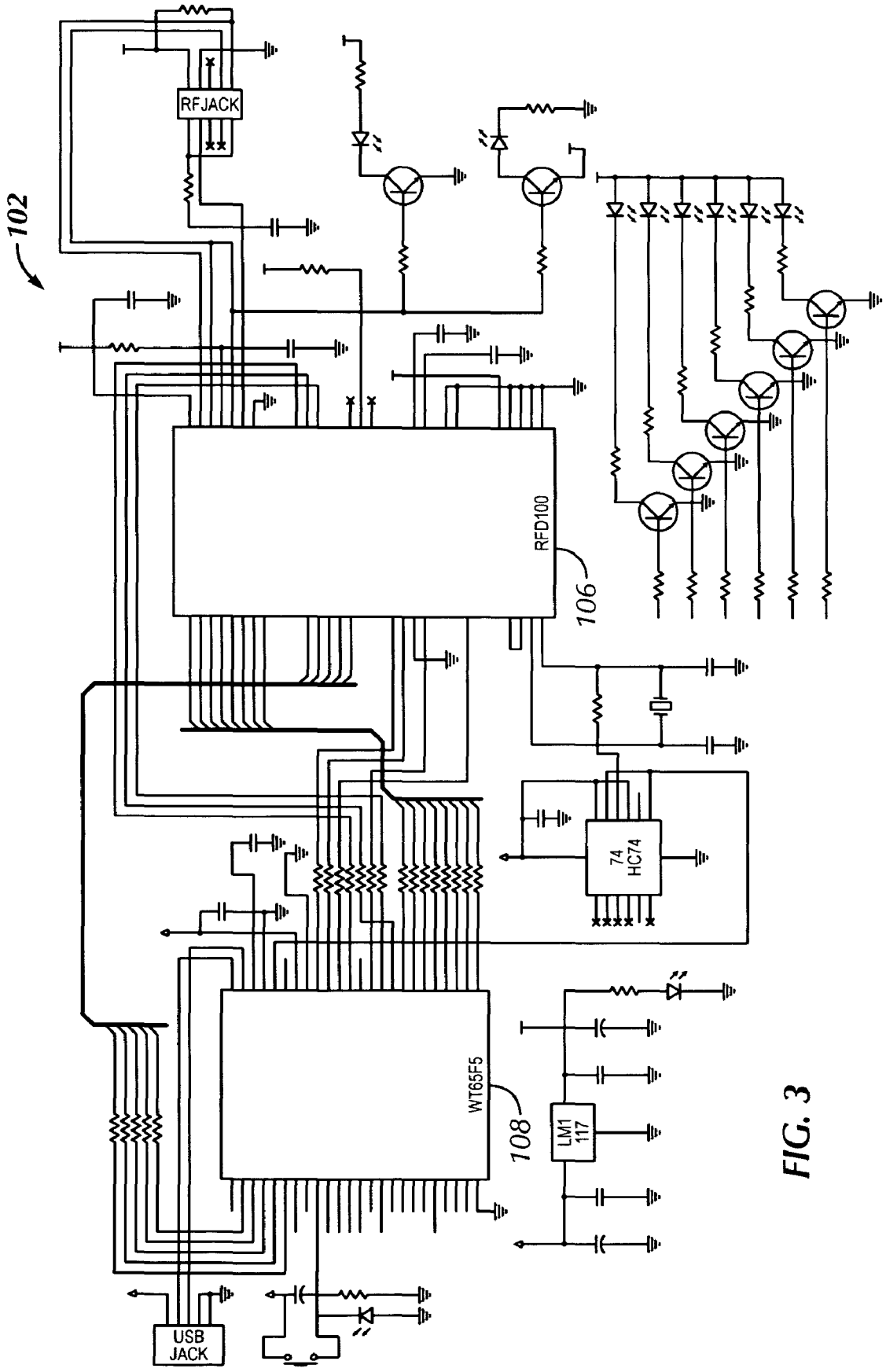


FIG. 3

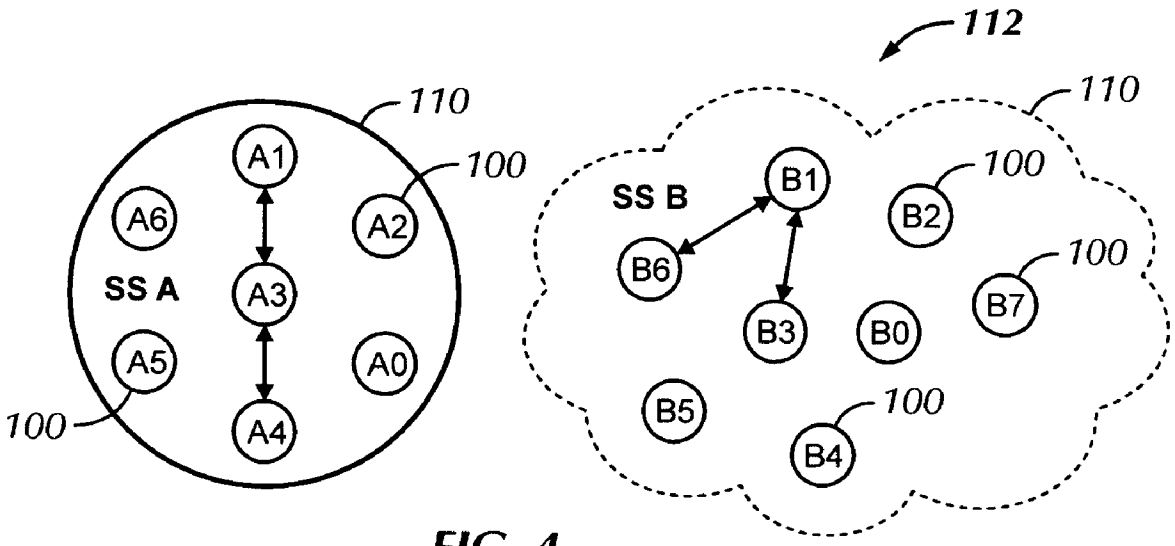

112
110
100
A1
A2
A3
A4
A5
A6
A0
SS A
100
110
100
SS B
B1
B2
B3
B4
B5
B6
B7
B0
100
100

FIG. 4

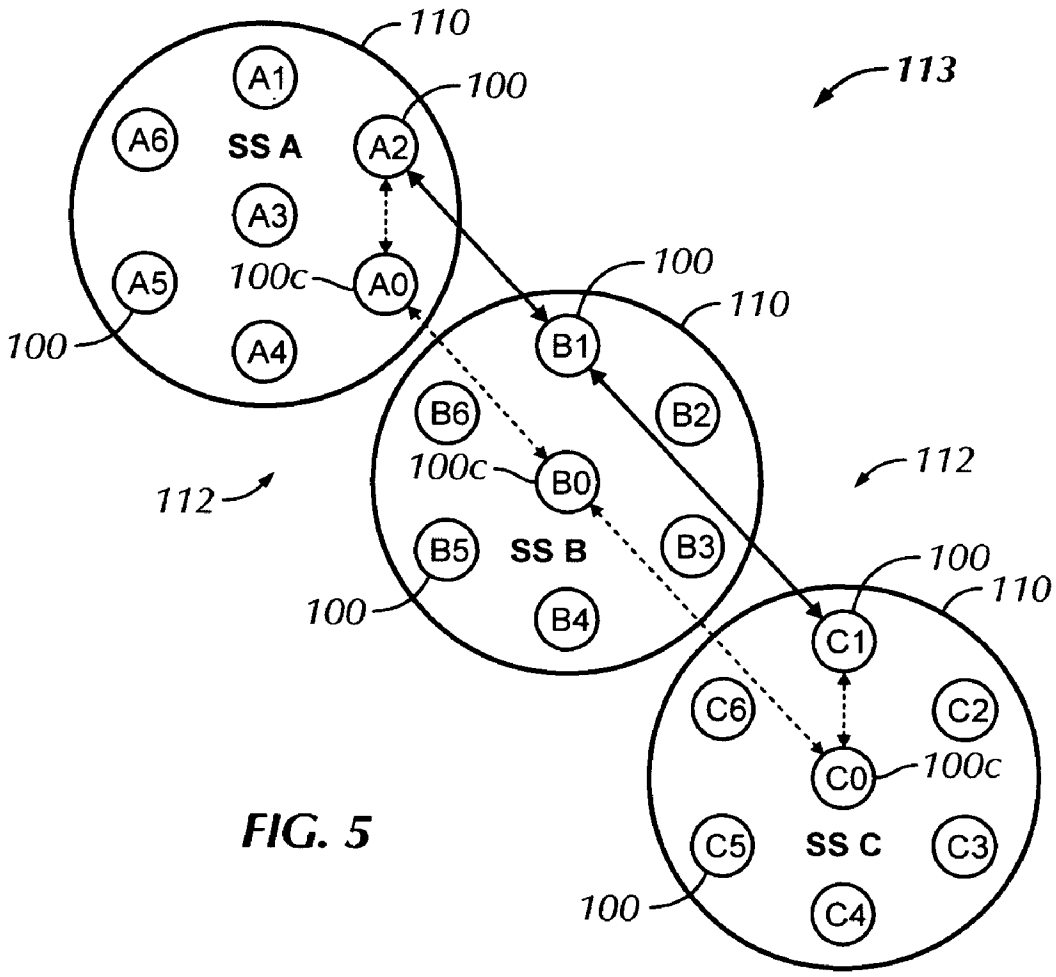

110
100
113
A1
A2
A3
A4
A5
A6
A0
SS A
100c
100
112
100
110
B1
B2
B3
B4
B5
B6
B0
SS B
100c
112
100
100
110
C1
C2
C3
C4
C5
C6
C0
SS C
100c
100

FIG. 5

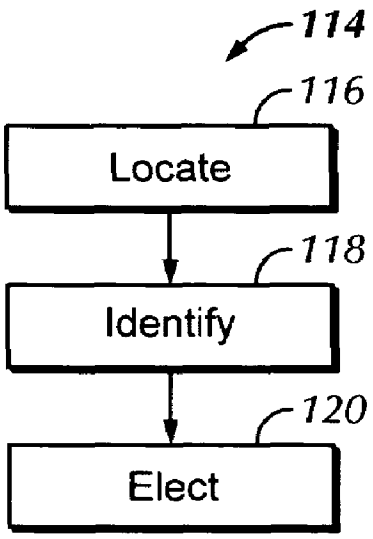


FIG. 6

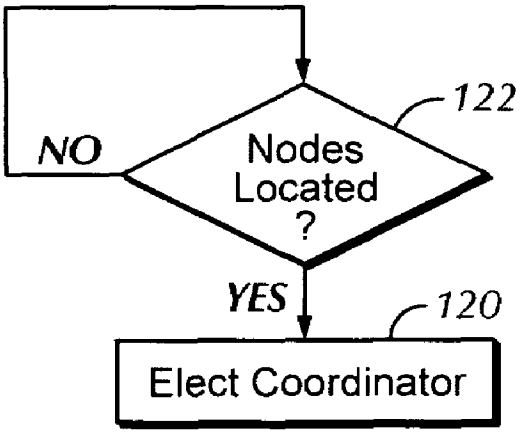


FIG. 7

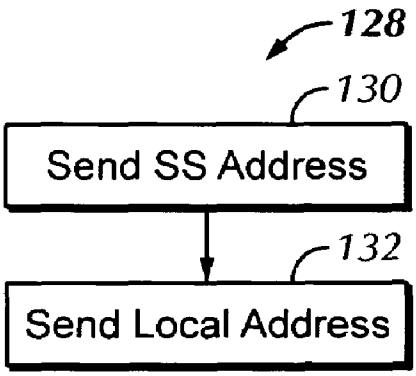


FIG. 8

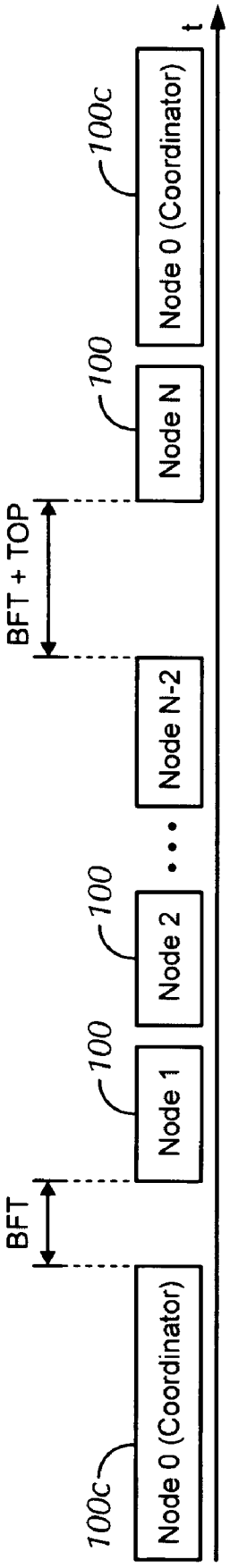

t
Node 0 (Coordinator)
100c
Node N
100
Node N-2
BFT + TOP
Node 2
100
Node 1
100
BFT
Node 0 (Coordinator)
100c

FIG. 9

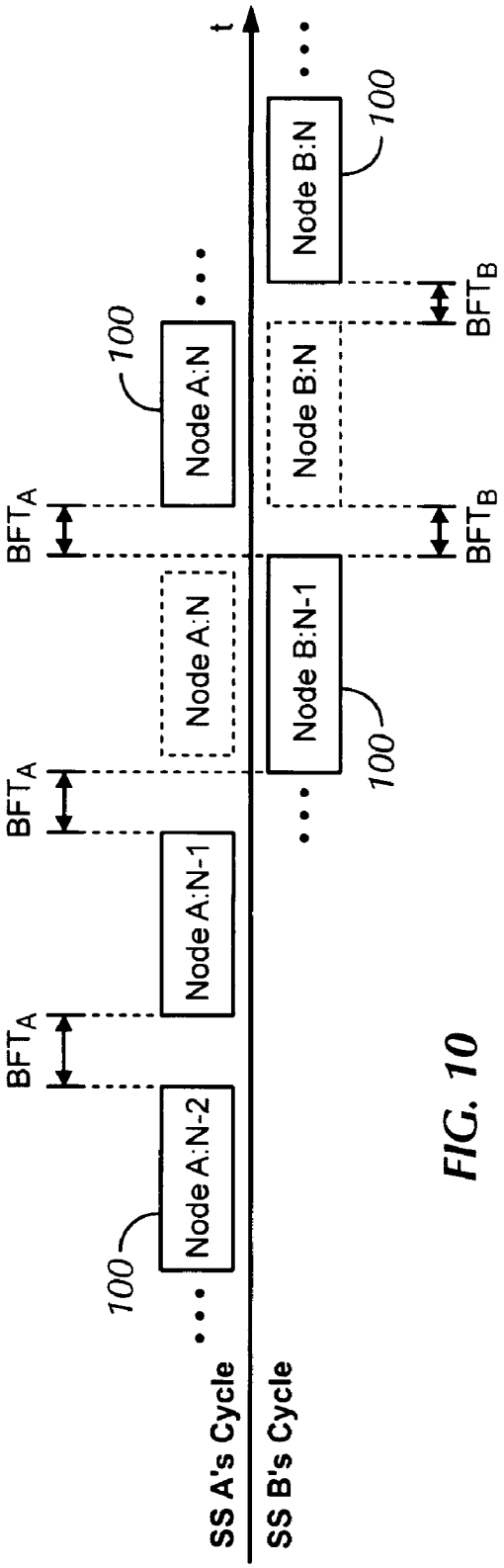

t
Node A:N
100
Node B:N
100
BFT_A
BFT_B
Node A:N
Node B:N-1
100
BFT_A
BFT_B
Node A:N-1
BFT_A
Node A:N-2
100
SS A's Cycle
SS B's Cycle

FIG. 10

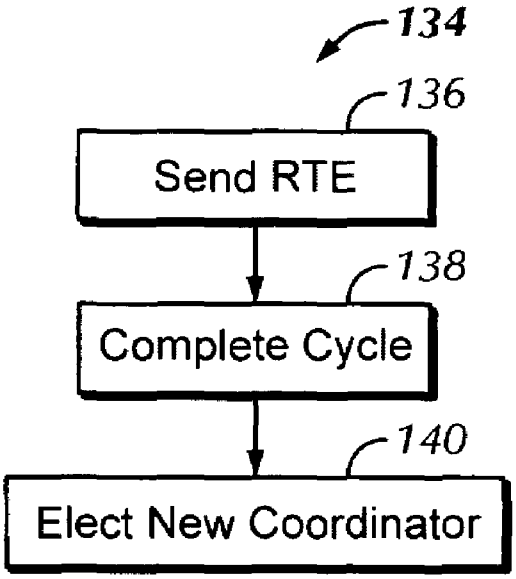

134
136
Send RTE
138
Complete Cycle
140
Elect New Coordinator

FIG. 9A

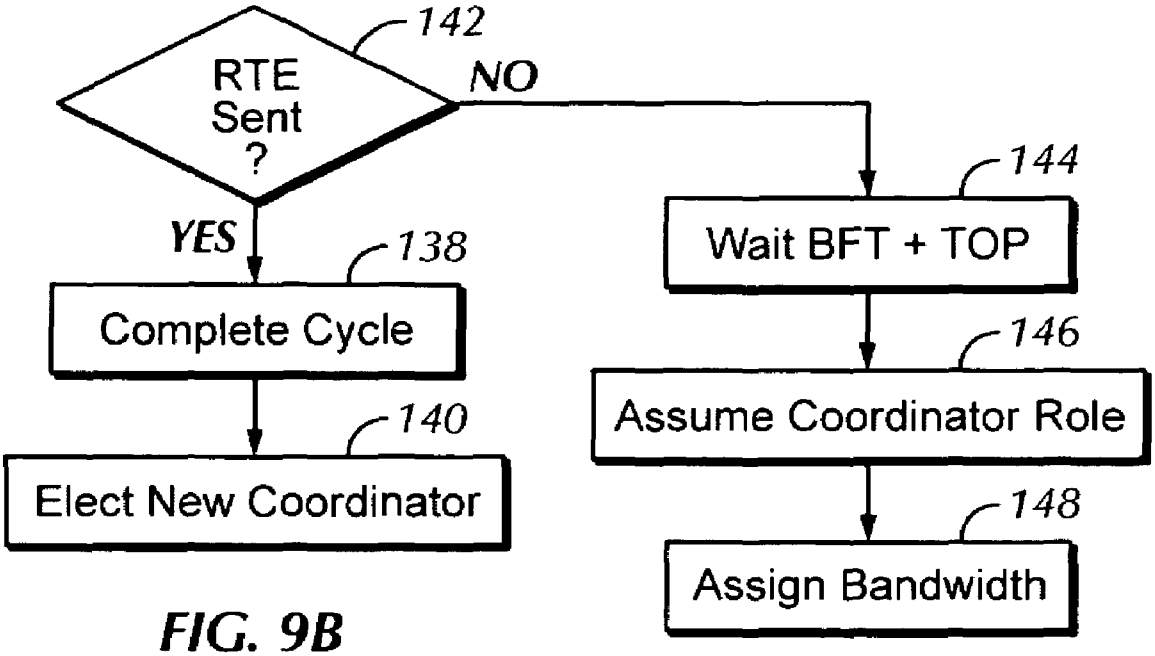

142
RTE Sent ?
NO
YES
138
Complete Cycle
140
Elect New Coordinator
144
Wait BFT + TOP
146
Assume Coordinator Role
148
Assign Bandwidth

FIG. 9B

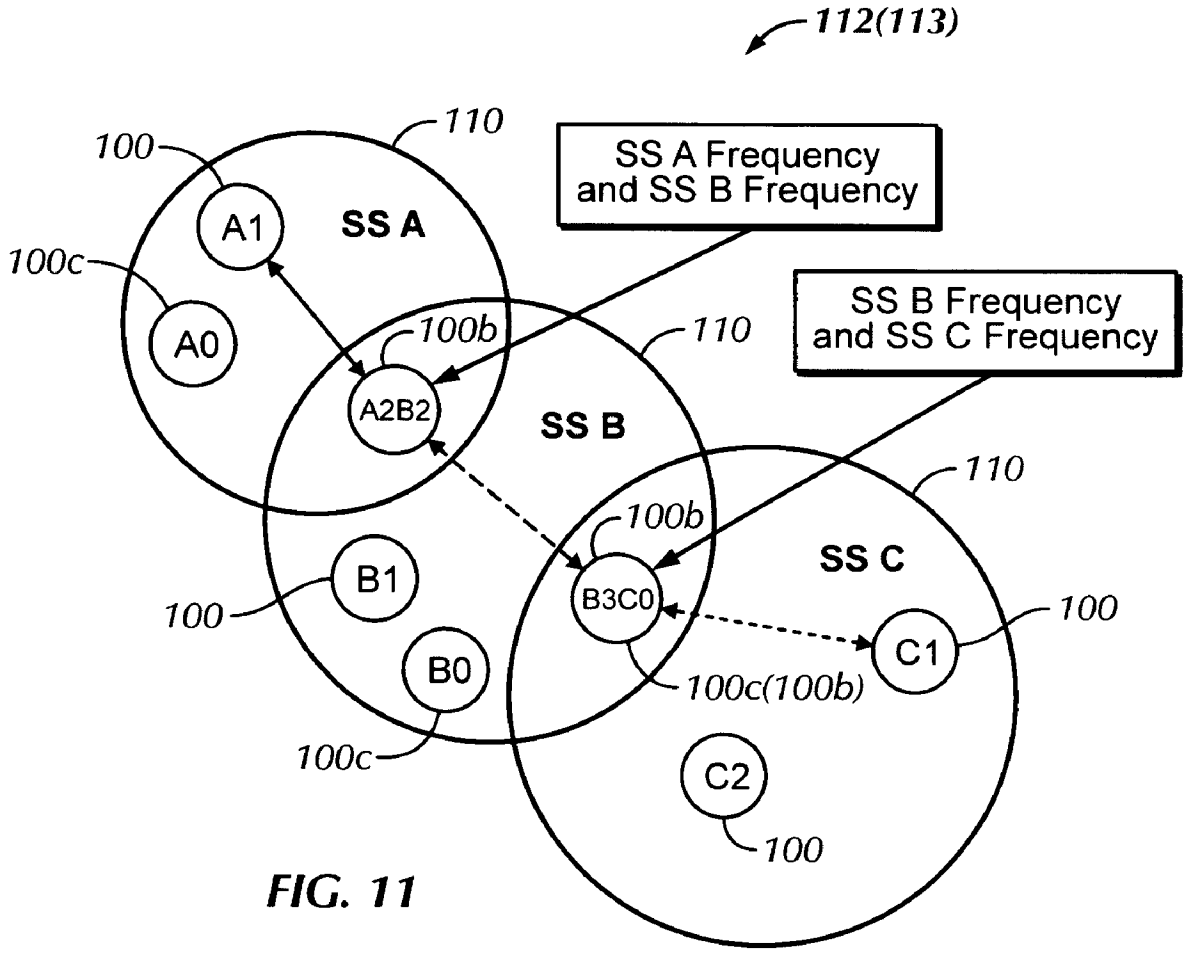

112(113)
110
100
SS A Frequency
and SS B Frequency
A1
SS A
100c
A0
100b
110
SS B Frequency
and SS C Frequency
A2B2
SS B
110
100b
SS C
B1
B3C0
100
100
C1
B0
100c(100b)
100c
C2
100

FIG. 11

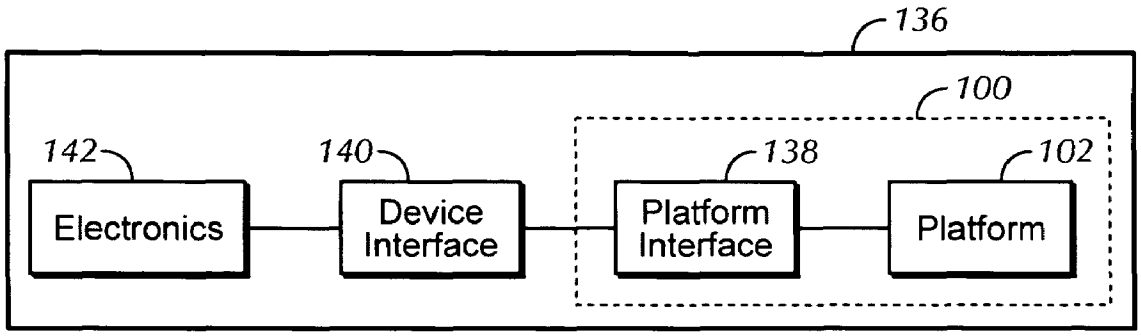

136
100
142
140
138
102
Electronics
Device Interface
Platform Interface
Platform

FIG. 12

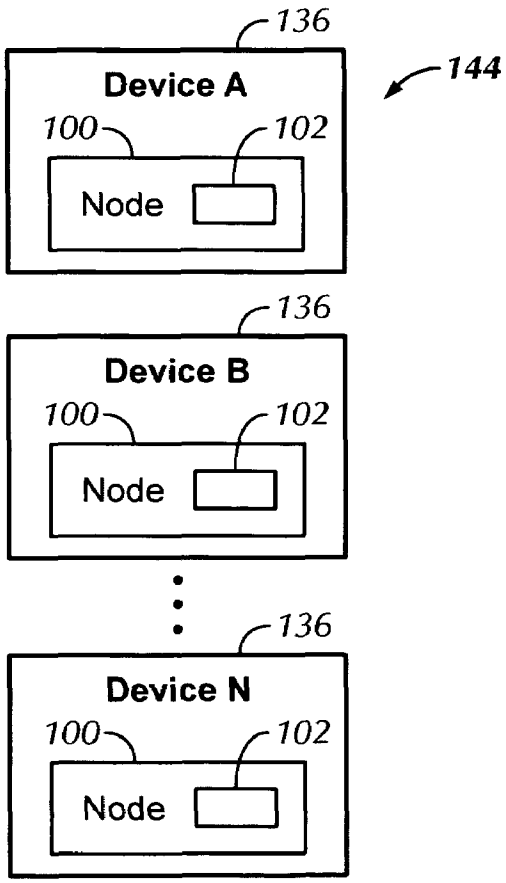

136
144
Device A
100
102
Node
136
Device B
100
102
Node
136
Device N
100
102
Node

FIG. 13

MULTI-TO-MULTI POINT AD-HOC WIRELESS DATA TRANSFER PROTOCOL

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority under 35 U.S.C. 119(e) on U.S. Provisional Application for Patent Ser. No. 60/566,897 filed Apr. 30, 2004, the entire disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to communication systems and, in particular, to wireless communication systems.

Examples of conventional wireless communications systems include Bluetooth and IEEE 802.11 protocols. The Bluetooth protocol is a strict hierarchical structure, while the IEEE 802.11 protocol is a pure flat layer structure. While conventional communications protocols provide effective wireless communications, there is a continued need in the art for improved wireless systems with enhanced qualities and parameters.

SUMMARY OF THE INVENTION

According to one of the aspects of the invention, a communication system utilizes a process for creating a multi-to-multi point, extendable, ad-hoc wireless network. The network's overall transfer rate and range may depend on the radio chipset technology used. The methods and apparatus of the invention enable a plurality of electronic devices to connect in an ad-hoc network.

The invention enjoys a number of advantages over conventional wireless data transfer software or firmware protocols and over similar applications that currently employ alternative radio technology. For example, the invention improves upon Bluetooth's strict hierarchical structure and the IEEE 802.11's pure flat layer structure. It provides a collision-free atmosphere in a single SS scenario and a fairly low collision probability in a multi-SS scenario.

Other features and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** illustrates the formation of a solar system (SS);

FIG. **2** is a block diagram of a hardware platform of the invention;

FIG. **3** is a schematic diagram of an example of a hardware platform;

FIG. **4** illustrates the formation of a galaxy;

FIG. **5** illustrates the formation and operation of multiple SSs in a galaxy and/or a universe according to a number of embodiments;

FIG. **6** illustrates methodology for forming an SS according to a first phase;

FIG. **7** illustrates methodology for electing a coordinating node of an SS;

FIG. **8** illustrates methodology for forming an SS according to a second phase;

FIG. **9** illustrates a round-robin allocation and use of bandwidth in an SS;

FIG. **9**A illustrates methodology when a coordinator exits an SS by sending a request;

FIG. **9**B illustrates methodology when a coordinator exits an SS without sending a request;

FIG. **10** illustrates the operation of a galaxy according to a number of embodiments;

FIG. **11** illustrates the operation of a multiple SSs in a galaxy and/or a universe according to a number of other embodiments;

FIG. **12** is a block diagram of a node implemented in an electronic device; and

FIG. **13** illustrates a plurality of node-equipped electronic devices.

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIG. **1**, the invention may be embodied in individual nodes **100**. A node **100** may include a hardware platform and either software or firmware. According to a number of embodiments, a hardware platform **102** as shown in FIG. **2** may include an antenna **104** (e.g., printed circuit board antenna or chip that acts as an antenna), a radio chipset **106** (e.g., RFWaves **102** and D100 radio chipset, or Nordic NRF905), and a microprocessor control unit (MCU) **108** (e.g., standard 8051, TI MSP320, or ARM7). A specific schematic example of the hardware platform **102** is illustrated in FIG. **3**. Source code may be either written on the MCU **108**, in which case it constitutes software, or embedded in the MCU **108**, in which case it constitutes firmware. Accordingly, the hardware platform **102** is configured to enable wireless communication of data.

A node **100** may be either connected to (e.g., by way of an external plug, key, dongle, or other interface), or embedded in, an electronic device. Examples of electronic applications are discussed below. A node **100** enables the electronic device to send data to, and receive data from, other electronic devices that are equipped with nodes **100**.

The nodes **100** transfer data directly among themselves by forming an organized ad-hoc network, or "solar system" (SS), which is indicated by reference numeral **110** in FIG. **4**, with the data transfer being indicated by the arrows. The nodes **100** within an SS **110** can also transfer data directly with nodes **100** in other SSs **110** when the nodes **100** are within the same given radio range, or "galaxy," which is indicated by reference numeral **112** in FIG. **5**, with the data transfer being indicated by arrows. In addition, the nodes **100** within one galaxy **112** can transfer data with nodes **100** in other galaxies **112** if their individual coordinating nodes and/or other nodes **100** within their respective SSs **110** are from contiguous galaxies **112**, or within the same "universe," which is indicated by reference numeral **113** and which is discussed in detail below.

An SS **110** may be formed in two phases as illustrated by formation methodology **114** of FIG. **6**. In the first phase, each of the nodes **100** may emit pings to locate other nodes **100** (step **116**) within a given radio range, broadcast their serial numbers, or "tags," to identify themselves (step **118**), and send out "Election Ballot" (EB) packets to elect a coordinator, or "sun," (step **120**) for the new SS **110**. These broadcasts may take place in a carrier-sense manner and may last for a set time period (for example, less than one second). When two or more nodes **100** locate each other and have sent out EB packets as shown by step **122** in FIG. **7**, the nodes **100** may automatically elect the node **100** (step **120**) with the highest serial number among them as coordinating node, or coordinator. This first phase methodology is also indicated by reference numeral **124** in FIG. **1**.

In the second phase as indicated by reference numeral **126** in FIG. **1** and by SS formation methodology **128** in FIG. **8**, the elected coordinator may send each node **100** an SS address (step **130**) and a local address (step **132**). The SS address is used to recognize the node's participation in the SS **110**. The local address is used to set each node's position in the SS's round-robin cycle for sending data to the other nodes **100** in the SS **110**. A node's data transmission attaches its SS and local addresses. After the nodes **100** receive their SS and local addresses from the coordinator, the SS **110** is ready for operation, and the nodes **100** can transfer data among themselves freely. As shown in FIG. **1**, the coordinator may acknowledge each of the nodes **100** with an SS address and a local address, which acknowledgements are indicated by Ack 0, Ack 1, . . . , Ack N.

With reference to FIG. **9**, after the nodes **100** establish an SS **110**, the coordinating node, or coordinator, which is indicated by **100**C, may allocate amounts of bandwidth to each node **100** on a rotating basis. During each rotation, the coordinator **100**C includes the amount of bandwidth allocated to each node **100** in the packet that the coordinator **100**C sends out to all the other nodes **100** in the SS **110**, and each node **100** includes its bandwidth request for the next round in the packet it sends out. The amount of bandwidth allocated to a node **100** may depend on the amount requested by the individual node **100** relative to the amount of bandwidth requested by all of the other nodes **100** in the SS **110**. This allocation process ensures that the SS **110** runs efficiently and is fair to all of the nodes **100**. This allocation process may be described as a round-robin allocation process. In FIG. **9**, N equals the total number of nodes **100** in the SS **110**, and t represents time.

As an operational example with reference to FIG. **9**, Node N is only allowed to transmit data after Node N−1 finishes its transmission and the wireless channel is free for a variable period of time known as the "Between Frame Time" (BFT). If at the time Node N−1 has nothing to transmit, Node N−1 keeps silent, and after the wireless channel is free for BFT plus a set period of time known as the "Time Out Period" (TOP) (i.e., BFT+TOP), Node N comes up and the round-robin or sequential cycle continues.

The data transmissions of each node **100** go to all of the other nodes **100** in the same SS **110**. Each node **100**, however, may process only the transmissions that were intended specifically for it (as signified by its local address). Each node **100** may include a filter to discard all other packets.

After an SS **110** has been established, nodes **100** may join or leave the SS **110** at any time. When a node **100** wants to leave an SS **110**, the node may wait until its turn in the round-robin cycle to transmit a "Request to Exit" (RTE) packet. When the coordinator **100**C receives the RTE packet, the coordinator **100**C may use a portion of its next slot in the round-robin cycle to reassign local addresses to all of the remaining nodes **100**, and the round-robin cycle continues uninterrupted. If a node **100** in the SS **110** does not transmit data for a set number of round-robin cycles, then the coordinator **100**C may automatically assume that the non-transmitting node **100** has left the SS **100**, and may reassign local addresses to all of the remaining nodes **100**.

When a node **100** wants to join an existing SS **110**, it must wait until the wireless channel is free for a set period of time known as the "Insert Waiting Time" (IWT), where IWT<BFT, to transmit a "Request to Join" (RTJ) packet. When the SS's coordinator **100**C receives the RTJ, the coordinator **100**C may use a portion of its next slot in the round-robin cycle to reassign local addresses to all of the nodes **100**, and the new node **100** may join the enlarged SS **110**. All nodes **100** that join an existing SS **110** submit to the original coordinator **100**C, even though they may have a higher serial number. The coordinator **100**C may be set to automatically accept or reject new nodes **100** or to respond to each new node's request separately.

Reference is made to FIG. **9**A for methodology **134** that may be utilized when a coordinator **100**C wants to exit an SS **110**. To exit an SS **110**, the coordinator **100**C may send an RTE packet (step **136**) to all of the nodes **100** in the SS **110**. When the nodes **100** receive the coordinator's RTE, the nodes **100** may finish the cycle in progress (step **138**) and then elect the remaining node **100** (step **140**) with the highest serial number among them to serve as the new coordinator **100**C. This process of electing a new coordinator **100**C may take less than one second. As shown in FIG. **9**B, if the coordinator **100**C exits the SS **110** without sending out a RTE packet (step **142**) (for example, in the case of an unexpected error), after waiting a period of BFT+TOP (step **144**), the first node in the SS (e.g., Node **1** as depicted in FIG. **9**) assumes the coordinator role (step **146**) and assigns an equal amount of bandwidth (step **148**) (preferably for the next round of broadcasts only) to each of the remaining nodes **100** in the SS **110**. The SS **110** then continues operating as described above.

When there are only two nodes **100** in an SS **110** and when one of the nodes **100** wants to leave the SS **100**, the leaving node **100** may send an RTE packet to the other node **100**, with the SS **110** being dissolved instantaneously. Both nodes **100** are then free to set up new SSs **110** or join other existing SSs **110**.

The nodes **100** within one SS **110** can communicate directly with nodes **100** in other SSs **110** if the individual nodes **100** are within the same given radio range, or "galaxy," as indicated by reference numeral **112** in FIG. **5**. An extended ad-hoc network, or "galaxy," may be formed when nodes **100** from two or more SSs **110** are within the same given radio range. The nodes **100** distinguish themselves in the galaxy **112** by their SS addresses and local addresses.

If a node **100** in one SS **110** wants to communicate directly with a node **100** in another SS **110**, the node may first listen for the data transmissions of the other nodes **100**. All of the nodes **100** within a given radio range receive the packets of other nodes **100** in the same radio range and frequency, although each node **100** may process only the packets intended specifically for it. If a node **100** does not receive another node's data transmissions, the node cannot communicate with the other node **100** directly. After the node **100** receives the other node's address details, the first node **100** can use its allocated bandwidth to send packets to the second node.

With reference to FIG. **5**, SS A may already be running when SS B emerges in the same given radio range and channel forming a galaxy **112**. Originally, Node A**2** of SS A could not communicate directly with Node B**1** of SS B because Node B**1** either did not exist or was located outside of Node A**1**'s radio range. Once SS B begins sharing the same given radio range and frequency as SS A, Node A**2** may receive all of Node B**1**'s data transmissions as well as Node B**1**'s SS and local addresses. Node A**2** may then use this information to send packets to Node B**1** and vice versa.

When nodes **100** from two or more SSs **110** form a galaxy **112**, the SSs **110** may share a common wireless channel in a competitive fashion. Each SS's round-robin cycle inserts into each other SS's BFT. With reference to FIG. **10**, the SSs **110** in a galaxy **112** may set their own BFTs. The lower an SS's BFT is set, the higher its share of the common wireless channel. An SS **110** with a low BFT has less chance of having its round-robin cycles interrupted by the insertions of other SSs' round-robin cycles. FIG. **10** shows how SSs **110** share a

common wireless channel in a galaxy **112**, where N equals the total number of nodes **100** in each SS **110** and t represents time.

When a new node **100** comes into a galaxy **112**, the node **100** may choose which SS **110** to join. The node **100** may first listen for each SS **110** in the galaxy **112** to complete at least one round-robin cycle. After receiving the address of each SS **110**, the new node **100** may send an RTJ packet to whichever SS **110** the node **100** may want to join.

When two or more nodes **100** want to establish a new SS **110** in an existing single-frequency galaxy **112**, the nodes **100** may each broadcast an EB packet, instead of an RTJ packet. All nodes **100** that broadcast EB packets form the new SS **110**.

In a number of embodiments, the nodes **100** within one galaxy **112** can transfer data with nodes **100** in other galaxies **112** in the same frequency provided their coordinating nodes **100** are from contiguous galaxies **112**, or within the same "universe," which is indicated by reference numeral **113** in FIG. **5**. An overall ad-hoc network, or "universe," is formed when coordinators from contiguous galaxies **112** using the same frequency establish a "Virtual Backbone Network" (VBN) for facilitating multi-hop data transfers among their nodes **100**. The coordinators **100**C act in a self-organizing manner to set up the VBN, and rely on nodes **100** within their SSs **110** to act as relay stations for transferring data between nodes **100** from different galaxies **112**. In these embodiments, a coordinator **100**C may also serve as a relay station.

Once an SS **110** is established in these embodiments, the coordinating node **100**C emits pings to broadcast information about its SS **110** and to locate all of the other coordinating nodes **100** within its galaxy **112**. Through this process, the coordinating node maps all of the other SSs **110** within its galaxy **112** and, by relying on the maps of the other coordinating nodes **100** within its galaxy **112**, gains a map of all of the galaxies **112** in the overall universe **113**. This process works by way of message diffusion similar to the OSPF routing protocol on the Internet. With these maps, the coordinators **100**C form a VBN for facilitating multi-hop data transfers among nodes **100** from different galaxies **112**.

The VBN of a universe **113** provides the routing information for multi-hop information relays between nodes in different galaxies **112**. When a node **100** in one galaxy **112** wants to send data to a node **100** in a different galaxy **112**, it first attempts to locate the other node **110** by sending a "Search Request" (SR) packet to its SS coordinator **100**C (which is indicated by A**0**, B**0**, and C**0** in FIG. **5**). The coordinator **100**C transmits this request to all of the coordinators **100**C within its own galaxy **112**. If these coordinators **100**C do not locate the node **100** in one of their SSs **110**, then these coordinators **100**C pass on the search request to all of the other coordinators **100**C in their galaxies **112**. Eventually, the search request spreads throughout all of the galaxies **112** in the universe **113**.

If the node **100** is found, the node's coordinator **100**C sends a response through the chain of coordinators **100**C back to the original coordinator **100**C. The coordinators **100**C also establish an efficient chain of nodes **100**, or relay stations, to conduct data transfers between the requesting node **100** and the responsive node **100**. Each coordinator **100**C may distribute the relay work among the nodes **100** in its SSs **110** equally, or may otherwise ensure that a relay node is not disadvantaged (relative to the other nodes in the SS) by the relay work. If the responsive node **100** is not found within a certain time period, the original coordinator **100**C sends a "Not Found" packet to the requesting node **100**.

In the example shown in FIG. **5**, SS A and SS B are in the same galaxy **112**, and SS B and SS C are in the same galaxy **112**. Nodes A**2** and C**1** cannot contact each other directly because they are not within the same given radio range. Node A**2** therefore sends an SR packet for Node C**1** to its coordinator A**0**. Coordinator A**0** transmits this packet to coordinator B**0**, which relays it to coordinator C**0**. Coordinator C**0** responds through coordinator B**0** that C**1** is in its SS, and coordinators C**0**, B**0**, and A**0** then establish a multi-hop connection using Node B**1** as a relay station to facilitate data transfers between Nodes A**2** and C**1**. Coordinator B**0**'s selection of Node B**1** to serve as the relay station for this data transfer may be based on an equal distribution of relay work within SS B or otherwise to ensure that Node B**1** is not disadvantaged (relative to the other nodes in SS B) by the relay work.

In addition to the example shown in FIG. **5**, in a number of embodiments, two or more SSs **110** in the same radio range may use different frequency bands, and the same frequency bands may be used by additional SSs **110** outside the respective radio ranges of the original SSs **110**. A group of nodes **100** may establish a new SS **110** in a distinct radio frequency (within the same radio range, or galaxy **112**, as other SSs **110**) by scanning the useable radio channels and selecting an available frequency to form their own SS **110**. The nodes **100** in the new SS **110** may then communicate with nodes in other SSs **110** within the same galaxy **112** (and, by extension, overall universe **113**) through the use of bridge nodes **100**B, such as shown in FIG. **11**.

The bridge nodes **100**B may operate simultaneously on two channels, the frequency used by their own SS **110** and a frequency used by another SS **110** within the same radio range, or galaxy, as shown by the dashed and solid lines in FIG. **11**. The bridge nodes **100**B may scan other frequencies within their radio range to discover and link to other SSs **110**. In these embodiments, the coordinating nodes **100**C may work with the bridge nodes **100**B to compose a virtual backbone network (VBN) across a galaxy **112** and universe **113**. The coordinating nodes **100**C continue to facilitate, or direct, data transfers among nodes in different SSs **110**, while the bridge nodes **100**B transfer, or relay, all inter-SS data packets. In FIG. **11** the SSs **110** may be in the same galaxy **112** (if they are in the same radio range) or universe **113** (if SS B belongs to the galaxies of both SS A and SS C). There may be more than one bridge node **100**B (operating on different frequencies) in an SS **110**, as shown in SS B in FIG. **11**, and the coordinating node **100**C for an SS **110** may also serve as a bridge node **100**B, as exemplified in SS C in FIG. **11**. By significantly reducing radio interference between SSs **110** within a given radio range, these embodiments of the invention increase the system's operating capacity and reduce power consumption.

With reference to FIG. **12**, to incorporate a node **100** in an electronic device **136**, the node **100** may include a platform interface **138** that is connectable to a device interface **140**, which in turn is in communication with electronics **142** of the device **136**. In some of the embodiments, the platform interface **138** may be incorporated unitarily with the hardware platform **102**, or may be a separate board or device. Accordingly, as shown in FIG. **13**, a plurality of node-equipped electronic devices **136** may define a wireless network **144** of electronic devices **136**. Examples of electronic devices are provided below.

In other embodiments, the hardware platform **102** may be embedded in the device **136**. In these embodiments, the hardware platform **102** may communicate directly with the device electronics **142**, thereby eliminating the need for the interfaces **138** and **140**.

Terminology

For the purposes of this description, a number of terms are used in describing the principles of the invention, including node, solar system, sun, galaxy, and universe. Explanations of how these terms are used follows.

A node **100** may consist of hardware and either software or firmware that together enable the node to send data to, and receive data from, other nodes **100**. Nodes **100** may be either connected to (e.g., by way of an external plug, key, or dongle) or embedded in electronic devices **140**, and thus enable such electronic devices **140** to communicate with each other. All nodes **100** may be stamped with a globally identifiable serial number, or "tag." The tag may be a 64-bit binary number, and may be burned into the flash memory at the manufacturing facility. A tag distinguishes each node **100**. After an SS **110** is formed, each node **100** in the SS **110** is assigned an SS address and a local address. These addresses distinguish each node within its SS **110**, galaxy **112**, and universe **113**.

Although all nodes **100** may be the same functionally, nodes **100** play different roles in the operation of an SS **110**. During the process of forming an SS **110**, the node **100** with the highest serial number is elected as the SS's coordinator **100**C, or "sun." The coordinating node **100**C assigns each node **100** in the SS **112** with an address, such as an 8-bit address. After the formation of the SS **110**, the coordinator **100**C uses this address to allocate bandwidth to each of the nodes **100** on a rotating basis. This allocation ensures that the nodes **100** in the SS **110** share the wireless channel in a collision-free manner. The coordinating node **100**C also facilitates data transfers between nodes **100** in its SS **110** and nodes **100** in other galaxies **112** by forming a "Virtual Backbone Network" (VBN) with coordinators from contiguous galaxies **112**, or within the same "universe" **113**. In some embodiments of the invention, the coordinators **100**C transfer data among each other through the use of bridge nodes **100**B that each operate on two frequencies.

An ad-hoc network, or "solar system" (SS) **112**, may be formed when two or more nodes **100** within a given radio range join together and elect a coordinator **100**C, which in turn assigns the nodes **100** local addresses for transferring data in a round-robin, collision-free manner. The local addresses can be based on the serial numbers of the nodes **100**, distance from the coordinator **100**C, or other factors, depending on the network's requirements. The nodes **100** act in a self-organizing manner to set up the SS **112**. Once the SS **112** is established, the nodes **100** in the SS **112** can transfer data among themselves freely. Nodes **100** can join or leave an SS **112** at any time. However, in a number of embodiments, the nodes **100** may be a part of only one SS **112** at any given time.

An extended ad-hoc network, or "galaxy" **112**, may be formed when nodes **100** from two or more SSs **112** are within the same given radio range. These nodes **100** may communicate directly with each other (if they are in the same radio range and share the same radio frequency). Nodes **100** can join or leave a galaxy **112**, and nodes **100** can be a part of multiple galaxies **112**. Nodes **100** can choose which SS **110** to join in a galaxy **112** or to form a new SS **110** in an existing galaxy **112**.

An overall ad-hoc network, or "universe" **113**, may be formed when coordinators **100**C from contiguous galaxies **112** establish a "Virtual Backbone Network" (VBN) for facilitating multi-hop data transfers among the respective nodes **100**. The coordinators **100**C act in a self-organizing manner to set up the VBN, and may rely on nodes **100** within their SSs **110** to bridge SSs operating on different frequencies or to otherwise serve as relay stations for transferring data between nodes **100** from different galaxies **112**.

Examples of Commercial Applications

The methods and apparatus have a number of applications with a number of devices (exemplified in FIG. **12**). For example, in the field of PC community data transfer and communications, the nodes **100** and associated methodology may be applied in word processing and document sharing, PowerPoint processing and presentation sharing, Excel processing and spreadsheet sharing, video game communities, e-mail processing, file sharing, and MSN, ICQ and other communication applications.

In the field of PC accessory data transfer and communications, the nodes **100** and associated methodology may be applied in printers, mouse controls, scanners, electronic cameras, headphones, MP3 players, PDA's, and speakers. In the field of audio and video communication devices, the nodes **100** and associated methodology may be applied in cell phones and cordless phones. In the field of home appliance data transfer, the nodes **100** and associated methodology may be applied in audio equipment such as stereos and speakers, televisions, refrigerators, air conditioners and heaters, coffee makers, and projectors. The nodes **100** and associated methodology may also be applied in animal and livestock tracking and in remote control toys (e.g., cars, boats, animals).

In the field of security system data transfer, the nodes **100** and associated methodology may be applied in sensor communication and coordination. In the field of automobile data transfer, the nodes **100** and associated methodology may be applied in crash sensors (e.g., car-to-car or car-to-railing) and car identification. In the field of meters and reading devices, the nodes **100** and associated methodology may be applied in meters for measuring water, gas, electricity, and parking duration. The nodes **100** may also be applied in location sensors to monitor the location and movement of objects within a given space.

Provided below is an example of a source code program which embodies the principles of the invention and represents the best mode to carry out the invention at this time.

Those skilled in the art will understand that the preceding embodiments of the present invention and the source code example provide the foundation for numerous alternatives and modifications thereto. These other modifications are also within the scope of the present invention. Accordingly, the present invention is not limited to that precisely as shown and described in the present invention.

What is claimed is:

1. A method for forming an ad-hoc network with a plurality of nodes, the method comprising:

electing a coordinating node from the plurality of nodes, the coordinating node then:

assigning an ad-hoc network address to each of the other nodes with the ad-hoc address recognizing participation of a respective node in the network; and

assigning a local address to each of the other nodes with the local address setting a position of a respective node in the network,

wherein the electing step comprises:

emitting pings from each of the nodes to locate nodes within a radio range; broadcasting a tag from each of the located nodes to identify each of the located nodes; sending out an election-ballot packet by each of the identified nodes to each of the other identified nodes,

wherein the electing step further comprises electing the coordinating node based on information in the tags,

wherein each of the tags includes a serial number, the electing step further comprises electing the node with the highest serial number.

2. The method of claim **1** wherein the coordinating node further allocates bandwidth to each of the nodes on a rotating, collision-free basis.

3. The method of claim **2** wherein the coordinating node allocates bandwidth based on an amount of bandwidth requested by all of the nodes in the network.

4. The method of claim **1** further comprising communicating data among each of the nodes in the network in a sequential cycle.

5. The method of claim **4** further comprising communicating data to one or more nodes in another ad-hoc network that is within radio range.

6. The method of claim **5** further comprising forming a virtual backbone network with the coordinating nodes in each of the networks.

7. The method of claim **5** wherein the coordinating nodes map all of the ad-hoc networks within a galaxy and/or universe.

8. The method of claim **5** wherein a node requests the coordinating node associated therewith to search for a node outside the ad-hoc network associated therewith, and wherein the coordinating nodes determine whether the node outside of the ad-hoc network is present.

9. The method of claim **5** wherein the coordinating nodes facilitate data transfers between nodes located in different radio ranges and/or frequencies.

10. The method of claim **5** wherein the coordinating nodes appoint and use one or more nodes to relay data transfers between nodes located in different radio ranges.

11. The method of claim **5** wherein the coordinating nodes rely on one or more bridge nodes that each operate on two radio frequencies to relay data transfers between nodes located in different radio frequencies and/or ranges.

12. The method of claim **1** wherein the coordinating node further recognizes that a node is leaving the network.

13. The method of claim **1** wherein the coordinating node recognizes that a node wants to join the network.

14. The method of claim **1** wherein the coordinating node transfers coordinating duties thereof to another one of the nodes within the network.

15. The method of claim **1** wherein the coordinating node leaves the network without notification, the method further comprising one of the nodes assuming role of coordinating node for the network.

16. The method of claim **1** wherein the coordinator node assigns new addresses to the nodes in the network and shares the new addresses with the coordinating node in at least one other ad-hoc network within radio range.

17. The method of claim **1** wherein at least one of the nodes is designated as a bridge node which periodically monitors other ad-hoc networks operating on different frequencies within the same radio range.

18. The method of claim **17** wherein the bridge node operates simultaneously on two radio frequencies and in two ad-hoc networks.

19. The method of claim **17** wherein a plurality of ad-hoc networks operate on the same frequency in different radio ranges and each include at least one bridge node, the plurality of ad-hoc networks being wirelessly connected together by the bridge nodes operating on other frequencies.

20. The method of claim **1** wherein the nodes establish the network on an available frequency in a radio range with other existing ad-hoc networks operating on other frequencies.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,593,374 B2
APPLICATION NO. : 11/121837
DATED : September 22, 2009
INVENTOR(S) : Lin Zhang

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Col. 9 lines 2-3
The last line of Claim 1 should read "the electing step further comprises electing the coordinating node based on its serial number."

Signed and Sealed this

Ninth Day of November, 2010

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office